

## Community Power Corporation

Subcontractor: Community Power Corporation  
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Contracting Party: Midwest Research Laboratory, National Renewable Energy Laboratory  
Division

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### Introduction

Based on Community Power Corporation's (CPC) need for large numbers of small biopower systems for rural electrification projects in Indonesia and its inability to purchase a commercially proven system, in 1997 CPC formulated a strategy to develop a family of SMB systems to electrify off-grid communities. In January 1998, CPC created a new biopower division with the collaboration of Dr. Thomas B. Reed, an internationally recognized expert on gasifiers. Based on CPC's preliminary assessment of market requirements, Dr. Reed identified several necessary improvements to current state-of-the-art SMB systems. Compared to current power gasifiers, these improvements focused on developing a new modular "Turn Key, Tar Free" high-energy gasifier, much smaller in size, with fewer components, no liquid effluents or hazardous wastes, much lower capital and operating costs, reduced maintenance, minimal civil works, and greater load-following capability.

Under Phase 1 of the SMB project, CPC conducted market and biomass resource assessments for 12- to 25-kWe SMB systems in three countries: Indonesia, Brazil, and the Philippines. These field studies showed conclusively that there was a significant and growing rural electrification market for CPC's SMB system.

The objectives of Phase 1 were as follows:

1. Identify potential markets for CPC's proposed SMB system.
2. Define the characteristics of the system required by the markets.
3. Identify technical issues to be resolved for the systems to meet market requirements.
4. Identify and evaluate the environmental issues associated with the proposed system.
5. Investigate strategic partnerships required to finance the business development.
6. Develop a detailed engineering design study for the prototype SMB system.
7. Perform a preliminary hazard and operability study of the prototype.

The accomplishments during Phase 1 were as follows:

#### Market and Pilot Project Identification

- Conducted successful market assessment in Indonesia, Brazil, and the Philippines.
- Identified community power and rural industries markets for (12 to 25kWe) SMB systems in the Philippines (2000), Indonesia (5000), Brazil (2000), and Alaska/United States (TBD).
- Began preparing two specific pilot project sites to demonstrate CPC's SMB system in the Philippines.
- Identified additional pilot project sites for CPC's SMB system in Indonesia and Brazil.

### SMB System Design and Development

- Developed a set of detailed market-driven specifications for CPC's new SMB system based on the comprehensive, on-the-ground market and customer surveys in three countries.
- Assembled a world-class design and engineering team to develop CPC's SMB prototype.
- Designed, fabricated, and tested a pre-prototype SMB power gasifier, including cleaning and cooling components, automated fuel feeder, and ash extraction system, and full instrumentation and data logging systems. At this time, 15 fully instrumented runs of the pre-prototype power gasifier have been conducted to determine the optimal design and operating parameters for a CPC "Turn Key, Tar Free" power gasifier during Phase 2. The pre-prototype system was demonstrated at NREL on September 14, 1999.

### Strategic Relationships

- Established a formal strategic relationship with Shell Renewables (SR) to commercially develop CPC's SMB system and to apply the system in rural electrification projects.
- In the Philippines, established formal relationships through MOUs and MOAs with two provincial governments, electric cooperatives, and the Philippines Coconut Authority for two SMB pilot projects.
- Established a relationship with the Development Bank of the Philippines to finance SMB system applications.

### **Potential Markets**

During Phase 1, CPC conducted field-based market studies for its SMB system in the Philippines, Indonesia, and Brazil. These studies showed conclusively that the primary market for CPC's SMB system is the electrification of off-grid communities. Two related markets were also identified for electrical and thermal energy for small-scale rural industries (agro-processing, crop drying, ice making, light manufacturing) and community needs for hot water and cooking.

There are more than 100,000 unelectrified communities in the Philippines, Indonesia, and Brazil. About 70,000 (70%) are in Indonesia, 20,000 (20%) in Brazil, and about 10,000 (10%) in the Philippines. About 50% or 50,000 are inaccessible because the lack of roads, do not have a sustainable biomass source, or are candidates for electrification by the utility during the next 10 years. Of the remaining 50,000 communities, about one half, or about 25,000 communities could pay for energy services from an SMB system. CPC's experience suggests that the potential sales of SMB systems in these countries over a 10-year period would be 2000 to 3000 systems or roughly 10% of the potential market. Of the three countries studied under Phase 1, the Philippines was selected as the most promising near-term market because of its stability, strong economic growth, abundant and appropriate agricultural residues (coconut shells and corn cobs), and strong government support for private sector participation in rural electrification projects.

### Philippines: Markets for CPC's SMB Systems

With 70 million people, 7107 islands, a strong and growing economy, a stable government focused on sustainable rural development, and more than 4 million rural households without access to electricity, the Philippines offers a readily accessible \$300 million annual market for renewable energy-based electricity services.

The same conditions that prohibit the use of conventional technologies make SMB systems ideal. The typical unelectrified region in the Philippines consists of hundreds of small clusters of 30 to 100 households surrounded by thousands of individual homes scattered throughout the countryside. In regions where coconut is the main

crop, CPC's SMB systems are ideal for providing compact communities with 220-V accelerated current electricity services. Rural enterprises and community services such as water pumping, street lights, health clinics, schools, churches, community centers, stores, and workshops can also be served by CPC's 10-to 25-kWe SMB systems.

#### Indonesia: Markets for CPC's SMB Systems

With 25 million unelectrified homes, mostly located in vast agricultural areas rich in biomass residues, Indonesia is an ideal market for SMB systems. CPC's 8 years of experience in Indonesia and field studies conducted under Phase 1 of the SMB project showed that more than half, or 12-15 million households (60,000 communities) are located in agriculturally rich and more prosperous agricultural regions. These rural households, which spend close to \$1 billion each year for inferior and environmentally damaging energy services from kerosene and automobile and dry cell batteries, constitute CPC's primary target market for SMB power systems in Indonesia.

CPC will access this market for SMB systems through its joint venture in Indonesia, PT. Bakrie Renewable Energy Systems (PT. BRES). Working in concert with various market aggregating sponsors, CPC will use SMB pilot projects to create the opportunity to serve the nearly 3000 unelectrified agricultural communities that have been established during the past three decades. PT. BRES will also initiate sales of SMB systems to one of the Bakrie Group's largest and most profitable business entities, Bakrie Sumatra Plantations (PT. BSP). PT. BSP is a major owner, operator, and developer of plantations for palm oil and rubber wood. Hundreds of communities located on PT. BSP's many plantations are without access to electricity and represent an attractive potential market.

#### Brazil: Markets for CPC's SMB Systems

CPC's field visit and market reconnaissance study in Brazil during Phase 1 showed that Brazil represents one of the world's largest potential markets for CPC's SMB power systems. However, because of the vastness of the country and a generally underdeveloped interior whose economy consists primarily of small-scale agriculture and forest products enterprises, supported by small, marginally accessible communities (typically with 20 to 50 homes), capturing and servicing this market presents a unique and difficult challenge. The typical household income in the target market communities is reported to be in the range of \$200 per month, which suggests an excellent ability to afford a basic level of energy services.

The long legacy of government-supported and -controlled monopolies for generating and distributing electricity and high-cross subsidies for rural electrification, is a barrier to opening up the unserved markets (rural and isolated communities) to a market-driven supply of energy services. However, the ongoing privatization of state-owned utilities, changes in regulation policies, and a gradual breakdown of service territory monopolies, are opening up new opportunities for the commercial supply of renewable energy-based power systems and energy services to unserved communities. Another positive factor is that biomass-based power generation for off-grid rural enterprises and small communities is considered by key government agencies as an appropriate and necessary alternative, over the long-term, to diesel-based power systems.

#### Biomass Resources in Target Markets

CPC's SMB system can be adapted to a variety of feedstocks as dictated by the specific target market for electrical and/or thermal energy. In the case of Indonesia, CPC's target markets for its SMB system are thousands of unelectrified plantation communities that house workers and staff for large palm oil and rubber plantations. The feedstock in these communities is either palm nutshells (a residue from palm oil mills) or

rubber wood from harvesting of non-productive trees. In the Philippines, CPC's initial target markets are off-grid communities located in regions where there is an abundance of coconut shells and corn cobs. In Brazil, CPC has identified markets in the Amazon basin and northeast regions where wood scraps and sawdust from small riverside sawmills, and nut shells (primarily ouricury and babasol) from local oil mills are plentiful local waste resources in thousands of communities.

The supply of relative small quantities of feedstock required by a community-based rural electric service company to operate one of CPC's SMB systems is not considered a problem for the following reasons.

- Only those communities with a secure, long-term supply of feedstock will be selected as potential users of CPC biopower systems.
- Given the extremely large number of unelectrified communities already identified by CPC in Indonesia, the Philippines, and Brazil, there is an immense and growing pool of potential communities and customers.
- The relative small amount of power required each day (~300 kWh @ ~20 kW peak) by communities in CPC's target markets requires a correspondingly small supply of feedstock (~300 kg/day/community).

#### Characteristics of Feedstocks in Target Countries and Markets

##### *Indonesia*

Indonesia is the world's second-largest producer of palm nut oil (more than 5 million tons/year from more than 200 mills) and a producer of more than 2 million tons of dry rubber and 60 million tons of rubber wood per year. Most production is located in CPC's target markets for the SMB system, so the selection of palm nut shells and non-productive rubber wood as the initial feedstocks was straightforward. Furthermore, CPC's joint venture partner, the Bakrie Group, is Indonesia's largest owner/operator of palm oil and rubber plantations and has just announced the startup of a \$1 billion, 70,000-hectare palm oil plantation in Kalimantan.

CPC's field visits to both palm oil and rubber plantations in Sumatra and Kalimantan discovered a strong willingness of the owners to supply the relative small quantities of these residues to local communities to generate electricity. In virtually all cases, use of these residues by local communities was welcomed by the mill owners because it meant a higher quality of life for their employees (who live in the largely unelectrified communities) and an increase in the consumption of waste products, thus reducing the burden of disposal.

##### *The Philippines*

The Philippines has an abundant and varied supply of biomass resources that include crop residues, forest residues, and agro-industrial wastes. The most common and available residues for power generation and thermal processing are bagasse, rice husks, and coconut shells and husks. Wood and wood waste are the largest sources of fuel for home cooking; 61% of the total population and 84% of rural population cook with fuel wood. Countrywide, the largest quantities of biomass residues come from three sources: sugarcane (24 million tons/year), coconut (12 million tons/year) and rice (11 million tons/year).

Based on field visits to various regions and assessments of biomass resources, CPC has determined that the initial demonstration project will demonstrate the use of two agricultural residues: coconut shells and corn cobs. In both cases the supply of the feedstocks will be from the residue of the communities' commercial activities that produce corn and coconut oil.

##### *Brazil*

As a result of CPC's field mission to Brazil (August 1998), five significant markets for SMB systems in the 10- to 25-kW range-including applications for village power, small sawmills and associated communities, small agricultural cooperatives, and a variety of rural industries in the Amazon Basin-were identified. Biomass resources associated with these applications include wood scraps and sawdust residues from sawmills and residues from agricultural crops such as palm oil and cacao.

## **CPC's SMB System Design**

The CPC SMB gasifier design is based on a thorough knowledge of the thermodynamics and kinetics of pyrolysis and charcoal gasification reactions, as well as 25 years experience with many kinds of gasifiers. The new CPC gasifier has been designed using the following parameters:

- Maximum superficial velocity (SV) in pyrolysis zone of 1 m/s
- Fuel consumption of 10 kg/h fuel (dry, ash free basis, DAF)
- Fuel velocity in pyrolysis zone 10 cm/min for woody biomass, 3 cm/min for densified biomass
- Gas production = 25 m<sup>3</sup>/h
- Energy content of gas @ 5 MJ/m<sup>3</sup> = 125 MJ/h
- Heat content/cooling load of gas (primarily N<sub>2</sub>) at 1000C = 1.3 MJ/m<sup>3</sup> × 32.5 MJ
- Gasifier efficiency = heat in gas/heat in fuel = 125/180 = 70%
- Gasification Air/Fuel (A/F) ratio – 1.5kg/kg, Dry, ash free fuel basis
- Total A/F ratio 6.0, DAF basis
- Pyrolytic gasifier diameter 10 cm
- Charcoal gasifier diameter 20 cm.

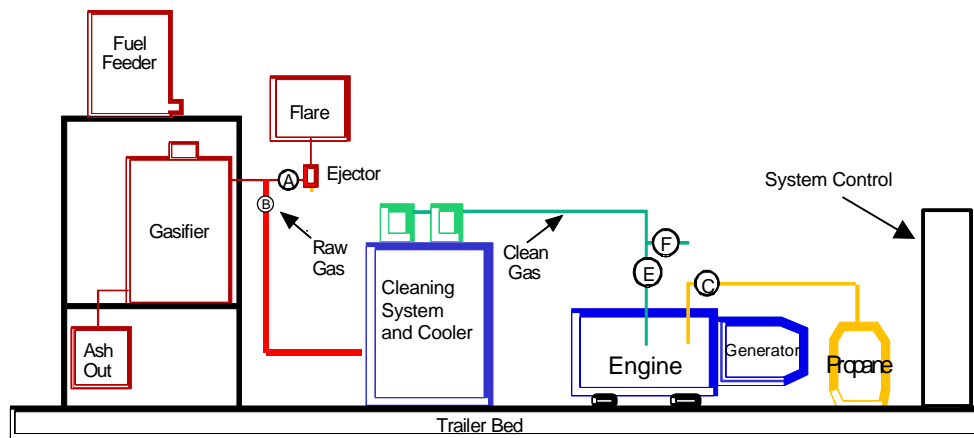
### Description of CPC's SMB System

The CPC system employs a downdraft gasifier coupled to a spark ICE generator set. The gasifier design incorporates features that result in high levels of carbon conversion with low tar production. These design and operating features produce an ash with physical properties that make it easier to separate from the gas stream. The CPC SMB system uses a dry gas cleanup technology and operation principles that prevent formation of liquid condensates. CPC's prototype SMB is self contained on a flat bed trailer having a footprint of 5 ft × 8 ft.

The CPC gasifier incorporates a flaming pyrolysis tube that generates charcoal centered in a larger plenum chamber, very well insulated at the bottom. A unique system of controlled injection of air for the final charcoal gasification process contributes to low tar and ash agglomeration. Agglomerated ash is automatically removed through a sealed opening in the base. Fuel is automatically fed to the gasifier. Figure 3 provides a simplified layout of CPC's SMB prototype system as of September 1999.

## **Future Development**

In Phase 2, through collaboration with SR, CPC will use its new bioenergy development facility in Denver, Colorado, to prepare a pre-commercial SMB system for a series of field trials in the Philippines where both electrical and thermal energy will be provided to off-grid communities and rural enterprises.



**Figure 3. CPC's SMB Prototype Components**

In cooperation with SR, CPC will continue a long-term program to develop and supply a family of field-proven and commercially viable SMBsystems to meet the growing global need for small, environmentally friendly, reliable, easily transportable and fully automated turnkey biopower systems.